Puget Sound Traffic Choices Study

Washington State Transportation Commission

November 16, 2005

Puget Sound Regional Council

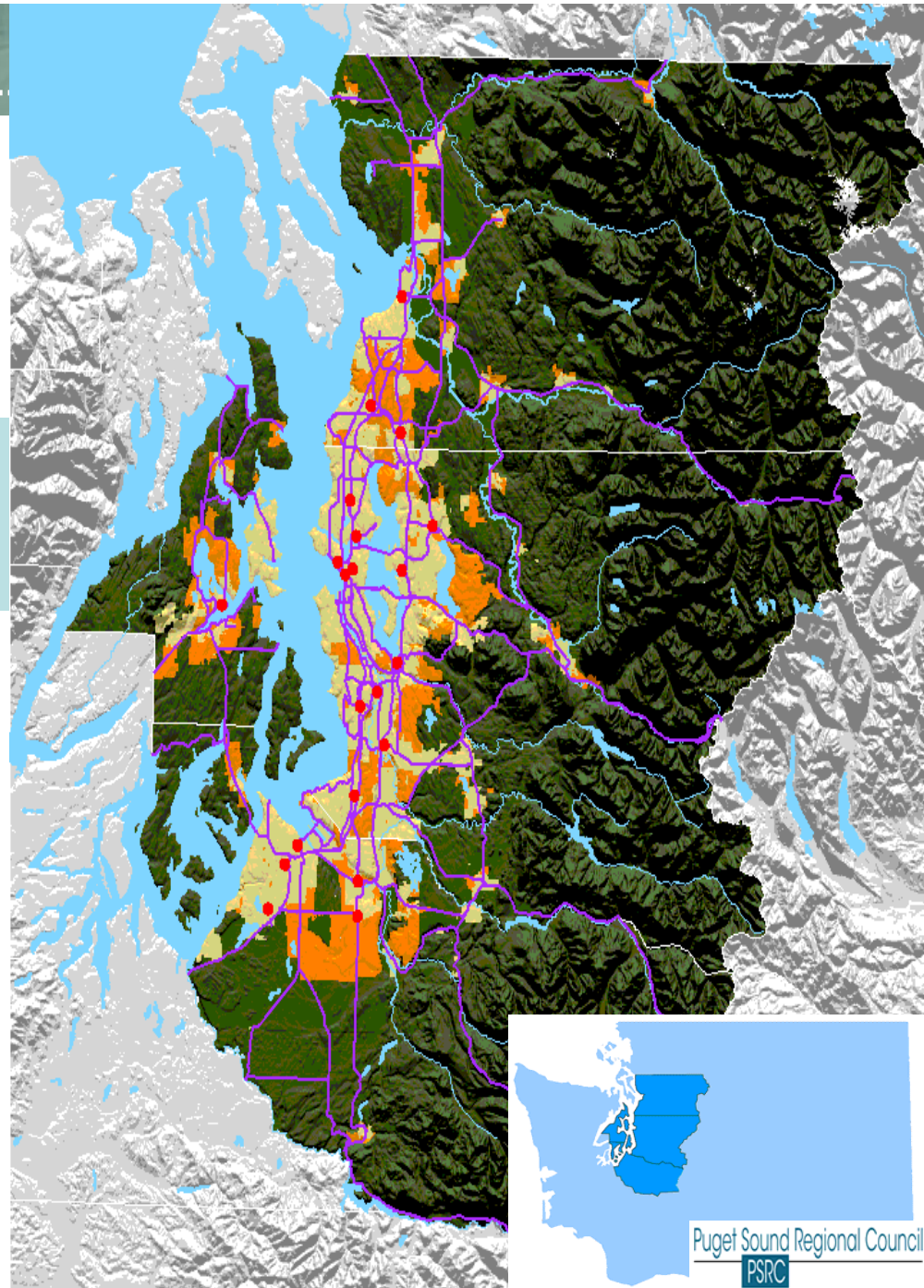
Washington State Department of Transportation

SIEMENS

Puget Sound Region

Puget Sound Regional Council
Metropolitan Planning Organization
designated under federal legislation

- 3.2 million people
- 1.7 million jobs
- 16,300 sq. kilometers
- Expecting significant growth over the next 25 years
- New growth will largely occur within existing urban areas



Existing Road Finance System

- **System is financially weak**
  - Poor fiscal elasticity of the gas tax, especially with new fuels
  - New capacity costs are rising with urbanization, and preservation and maintenance costs are rising as system ages
- **System performance is declining**
  - Congestion, road conditions deteriorating
  - Land use regulation, transit policy not obviating the problem
- **Gas tax (and other tax-based) finance perceived as unfair**
  - Expensive new capacity that benefits few taxpayers
  - Requires cross-subsidies, among regions, types of users
  - Hence, public support for general tax increase is marginal

How do we respond to growth in travel demand?

Through a variety of transportation investments:

- Additional roadway infrastructure
- High capacity transit investments
- Local buses (new service and priority treatments)
- Compact development patterns
- Employer-based demand management
- System management and information technology

But supply and demand remain out of balance!

All these approaches have limited effect, absent accurate pricing.

Future of Road Finance?

- **Conventional road finance is a vicious circle**
  - We levy a low charge on all mileage...
    - …creating excessive congestion during peak periods
  - The congestion prompts road authorities to build
  - But the low charges cannot cover the costs!
- **Demand pricing breaks the circle**
  - Charges are levied selectively on certain vehicle-miles
  - Controls excessive congestion during peak periods
  - Demand pricing generates the revenue to build capacity when it is really needed
  - Revenue is collected from those who burden capacity

Puget Sound Traffic Choices Study

Puget Sound Regional Council

Traffic Choices Study

The Traffic Choices Study is a federally funded pilot project that will test new ways to combat traffic congestion and fund transportation.

Our region will develop a better understanding of the policy and technical issues associated with road pricing, which will inform updates to the region's plans and influence decisions about our future.

Project Administration

USDOT/FHWA
Funding Agency
National Policy

Technical Advisory Group
PSRC
State DOT
US DOT
Toll Professionals
University of Washington

WSDOT
Fund Administration
Project Partner

PSRC
Project Lead

Consultants
ECONorthwest
Parsons Brinkerhoff
PRR

Systems Integrator
SIEMENS

Interested Parties
Business
Civic Groups
Communities
Media
User Groups
Tech. Industries

Study Participants

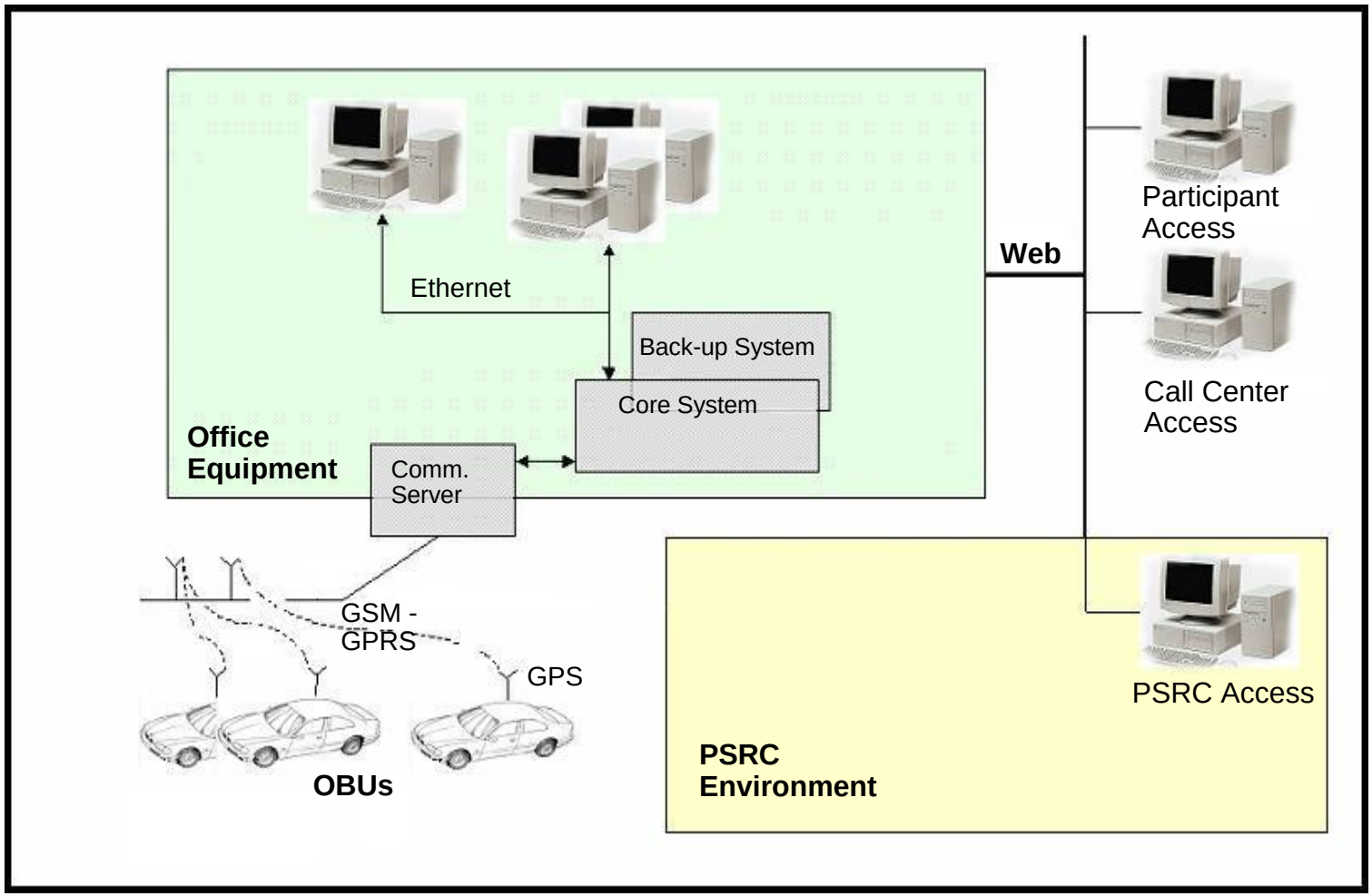
Project Objectives

- Familiarize real people with the concept of road pricing
- Learn whether drivers will pay to use a variety of roads
- Develop a better understanding of the policy and technical issues
- Test technology and program design

Key Attributes of the Project

- Pilot program to study effects of system-wide congestion pricing on traveling public within controlled research environment
- Groundwork for one future finance option for investments in Puget Sound's roadway network
- Use of existing off-the-shelf technology
- GPS-based tracking of vehicles
- GPRS/GSM communications between vehicle and central office
- "Hold-Harmless" billing using participant Endowment Accounts

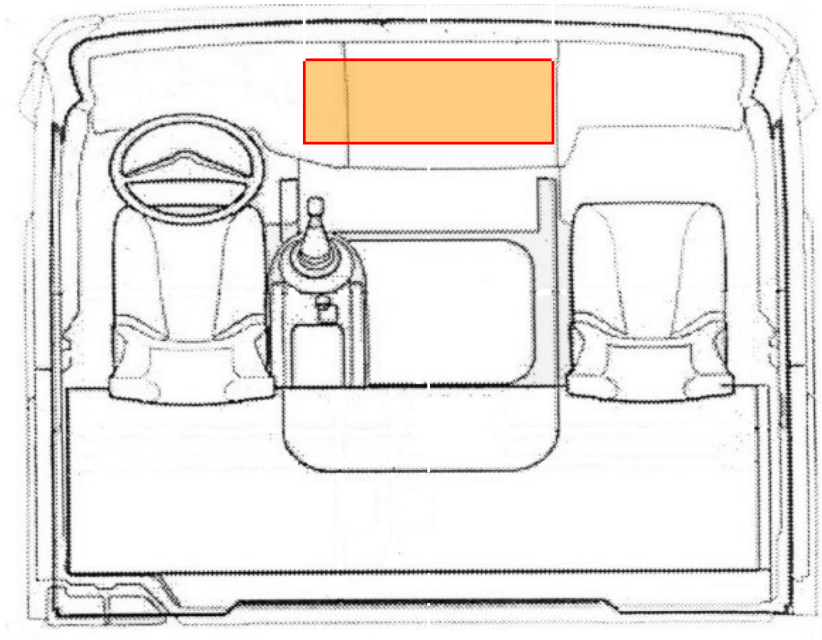
Overview of Main System Components



The On-Board Unit

- Internal GPS module
- Internal GPRS module
- Stores 8,000 link digital road network
- Software matches GPS signal returns to road links
- 2X16 character display (road name and toll/mile)

Mounting location



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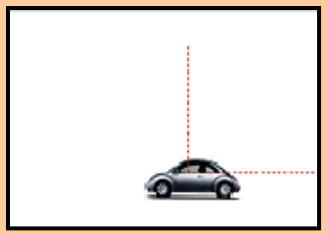
Start-up Period

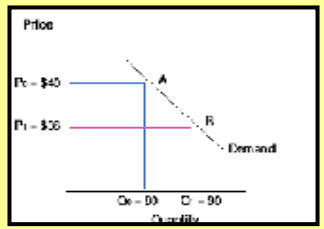
- Enroll participants
- Install in-vehicle equipment
- Baseline data collection
- Loaded system test
- Develop household travel budgets

Active Period



- In-vehicle toll display
- Driver modifies travel or pays toll
- Vehicle charged for road use
- Tolls levied against endowment accounts
- Participants keep unspent account balance

Analysis Period



- Calculate price elasticities
- Behavioral response
- Technical documentation
- Examine policy areas
- Full documentation of all aspects of the project

Pilot Implementation Schedule

System delivery

Acceptance test

Participant recruitment and enrollment

Pre-implementation	2005											2006			
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	Control			Experimental Treatment - Tolls								Control	Analysis		

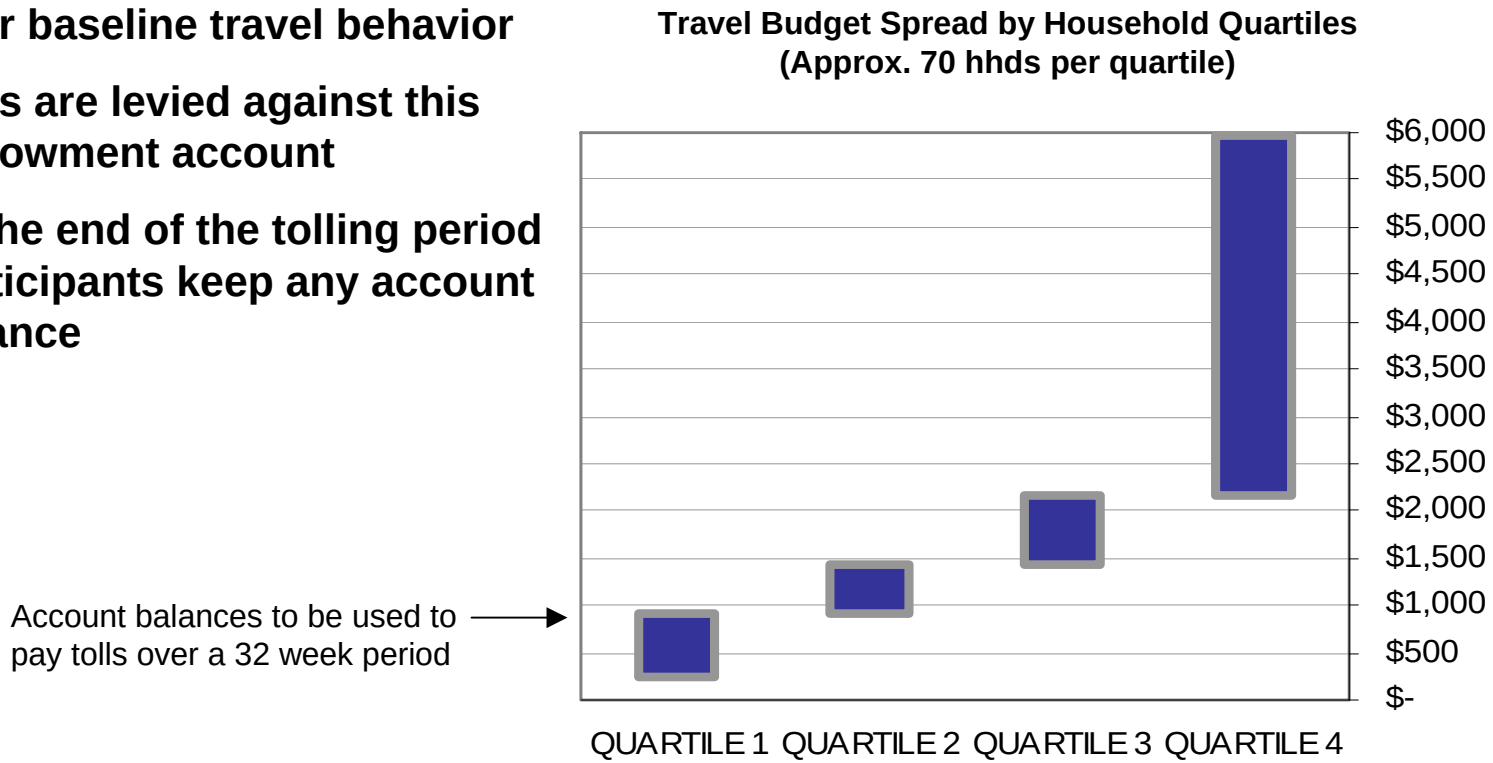
Crossover design - before and after control data

Participant Enrollment

- 275+ households
- 400+ vehicles
- Randomly selected from an enriched pool of potential participant households
- Sample enriched for likely respondents
  - Drivers exposed to congested roadway conditions
  - Households able to modify travel behavior through incentives

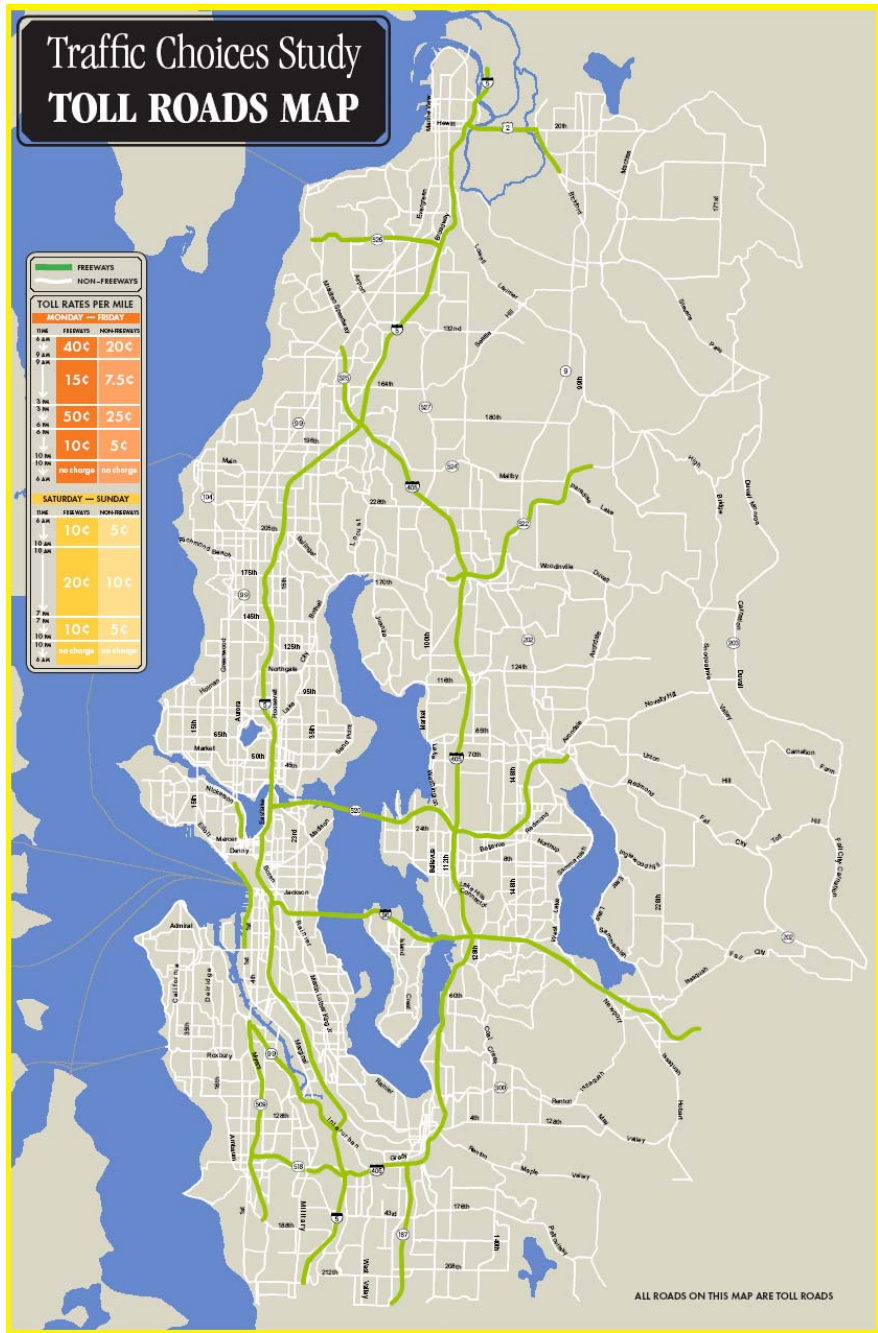
Participant Endowment Accounts

- **Each participating household is provided a unique travel endowment account, based on their baseline travel behavior**
- **Tolls are levied against this endowment account**
- **At the end of the tolling period participants keep any account balance**



Toll Roads

- **Highways and Major Arterials**
- **Tolls vary by:**
  - road facility type
  - weekday versus weekend
  - time of day



Tariff Model for Project

- **Based on theoretical "economic efficient" tolls**
  - Recognition of artificial tolling environment (pricing has no impact on ambient congestion)
  - Desirable to have an imperfect match of toll rates with conditions to generate variability for statistical modeling
- **Research objectives require multi-dimensionality**
  - Ideal: Variation of tolls by time of day, day of week, location, facility type and/or direction of travel
  - Practical: Emphasizes some dimensions while collapsing others
- **Simple, Simple, Simple**

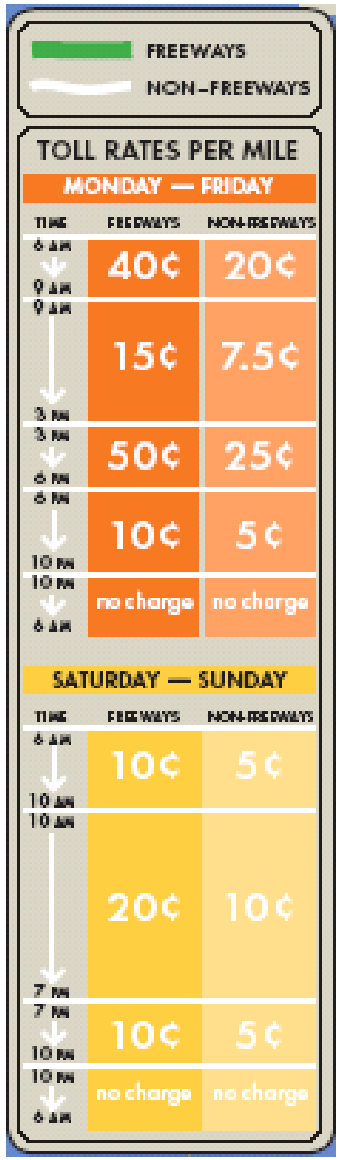
Toll Schedule

- **AM Peak - higher tolls**
- **Midday - lower tolls**
- **PM Peak - higher tolls**
- **Evening - lower tolls**
- **Night - zero tolls**

- **Weekday and weekend rates**

  During the weekend the midday has the highest tolls

- **Arterials are always ½ of the highway toll rates**



OBU Tolling Display

In the example on the right, the first toll road link has just been detected.

First Line:
The sum of all already detected links will be displayed.

Second Line:
The name of the link will be displayed, as well as the costs per mile for the link will be displayed for 10 seconds.

The second toll road link has just been detected.

Treatment of Location Data

- Current demonstration system involves high resolution location information leaving the vehicle to be stored in the central system.
- Privacy versus verification trade-off: limiting the extent of data that leaves the vehicle versus preserving audit/dispute functionality.
- OBU processing and storage capabilities are primary limiting factors. This can be changed… … it is only technology.
- Reliability - edge-heavy processing systems less reliable than center-heavy processing systems.

Example: Vehicle Trips

PSRC
Puget Sound Regional Council
Traffic Choices Project

kitchenm | Fri Feb 18, 2005 | 12:27:07 PM

- Home
- Project
- My Account
  - Balance
  - Invoices
  - Charged Links
  - Charged Trips
  - Personal Data
  - Troubleticket
  - Datamgmt
  - Participants
  - Vehicles
  - OBUs
  - Users
  - Tariffmgmt
  - Calendar
  - Version
  - Model
  - Links
  - Calendar Create
  - Systemgmt
  - File Upload
  - File Search
  - System Parameters
  - System Parameterset
  - System Log
  - Troubleticket (PSRC)
  - Participant's View

Participant's View

Select a participant and vehicle to get their bookings, lookup invoices and search locationstamps.

Participant	PSRC | TEST-VEHICLE [Choose Participant]
Vehicle	99999_01 | Ford Focus station wagon
From	02/01/2005
To	02/18/2005

[Search Trips] [Search Invoices] [Show Account]

31 result(s) found!

Trip ID	From - To	Total [miles]	Tolled [miles]	Zero Tolled [miles]	Non Tolled [miles]	Links	Locationstamps
1371763291/59355/44	Tue Feb 1, 2005 - 06:45:19 - Tue Feb 1, 2005 - 06:52:24	2.56	0.00	0.00	2.56		Show Locationstamps
1371763978/59356/44	Tue Feb 1, 2005 - 06:56:41 - Tue Feb 1, 2005 - 07:20:04	11.45	0.00	0.00	11.45	Show Links	Show Locationstamps
1371769985/59624/44	Tue Feb 1, 2005 - 08:38:21 - Tue Feb 1, 2005 - 09:10:38	12.33	1.21	0.00	11.12	Show Links	Show Locationstamps
1371796689/60314/44	Tue Feb 1, 2005 - 16:01:52 - Tue Feb 1, 2005 - 16:22:32	10.13	7.52	0.00	2.61	Show Links	Show Locationstamps
	Wed Feb 2, 2005 -						

Interim Review of Project Data

- Baseline control period and 15 weeks of experimental treatment
- Quick data review to gauge data quality and better understand post-experiment analysis “burdens”
- No econometric analysis
  - Do not yet have the benefit of the crossover control period
  - Have not yet built elasticity models, sample bias models
  - Have not yet controlled for fluctuations in fuel prices, or seasonality
- **All results presented are simply illustrative at this time**

Interim Review of Project Data

Descriptive Statistics – All Trips and by Time Period

	TOTAL	AM PEAK	PM PEAK	OTHER
Households	**269**			
Total trip records	293,826	38,852	76,238	178,736
Trips with tolled miles	218,742	32,425	59,269	127,048
Total miles driven	1,883,010	312,554	469,508	1,100,948
Total minutes driven	4,089,854	659,913	1,132,973	2,296,969
Total tolls	$ 240,292	$ 64,162	$ 100,224	$ 75,905
Average trip duration (minutes)	13.9	17.0	14.9	12.9
Average trip length (miles)	6.4	8.0	6.2	6.2
Average toll / trip	$ 0.82	$ 1.65	$ 1.31	$ 0.42
Percent trips with tolled miles	74%	83%	78%	71%
Average toll / trip with tolled miles	$ 1.10	$ 1.98	$ 1.69	$ 0.60
Average toll / mile	$ 0.13	$ 0.21	$ 0.21	$ 0.07
Average speed	27.6	28.4	24.9	28.8

Interim Review of Project Data

Descriptive Statistics – All Trips and by Weekday / Weekend

	TOTAL	WEEKDAYS	WEEKENDS
Households	**269**		
Total trip records	293,826	222,080	71,746
Trips with tolled miles	218,742	169,130	49,612
Total miles driven	1,883,010	1,395,748	487,263
Total minutes driven	4,089,854	3,142,090	947,764
Total tolls	$ 240,292	$ 206,762	$ 33,529
Average trip duration (minutes)	13.9	14.1	13.2
Average trip length (miles)	6.4	6.3	6.8
Average toll / trip	$ 0.82	$ 0.93	$ 0.47
Percent trips with tolled miles	74%	76%	69%
Average toll / trip with tolled miles	$ 1.10	$ 1.22	$ 0.68
Average toll / mile	$ 0.13	$ 0.15	$ 0.07
Average speed	27.6	26.7	30.8

Interim Review of Project Data

Descriptive Statistics – Average Daily Household Trips

	WEEKDAYS	WEEKENDS
Average daily household trips	8.9	7.1
Standard deviation	4.0	3.1

Descriptive Statistics – Average Weekday Tolls, All Households

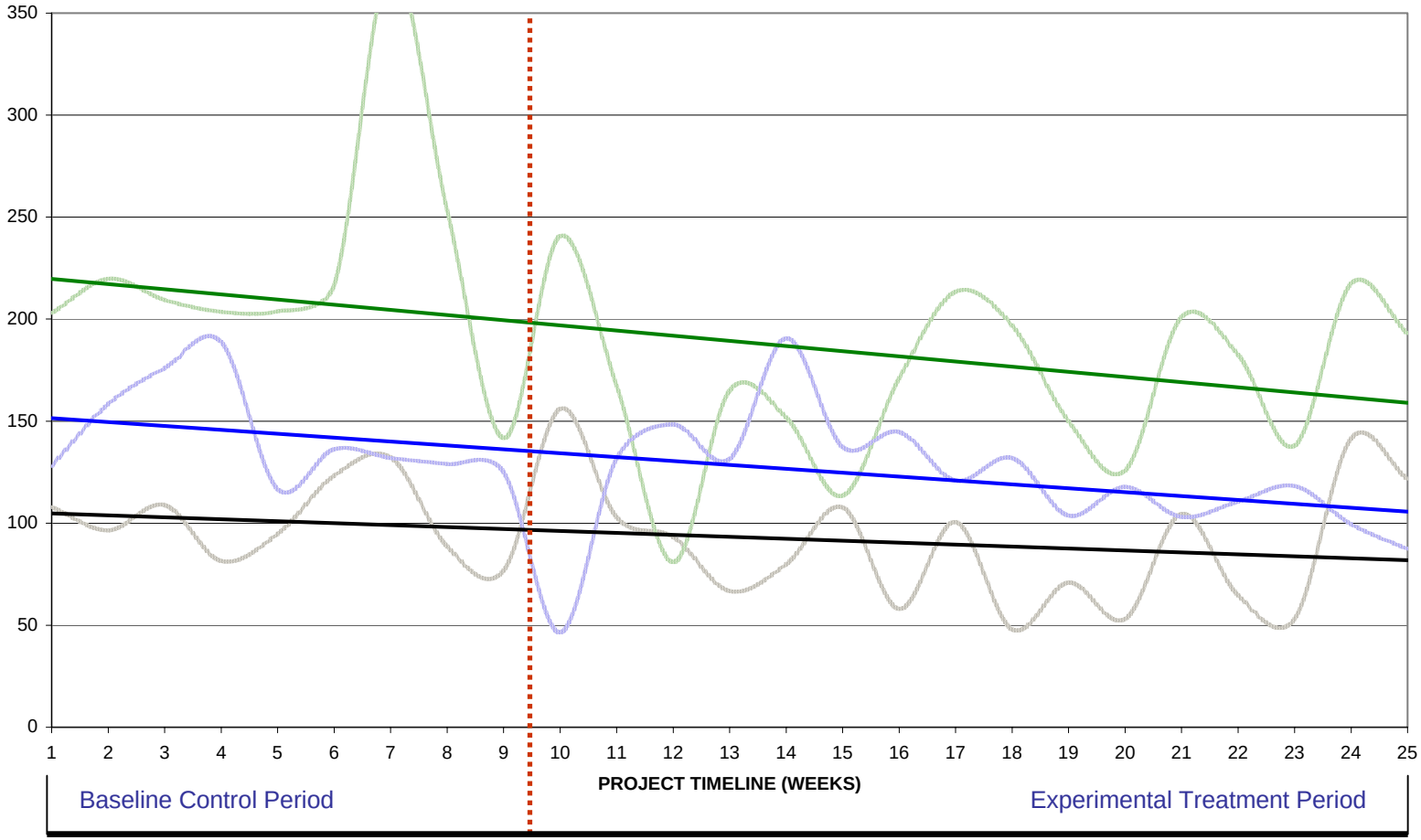
	WEEKDAYS AM PEAK	WEEKDAYS PM PEAK	WEEKDAYS OTHER
Average toll per trip	$ 2.65	$ 1.38	$ 0.40
Average toll per mile	$ 0.28	$ 0.20	$ 0.06

Descriptive Statistics – Tolls and Tolled Miles, Control and Experimental Periods

	CONTROL PERIOD	EXPERIMENTAL PERIOD
Average weekday tolled miles / household	35.9	36.2
Average weekday tolls / household	$ 8.14	$ 7.94

Interim Review of Project Data

3 Sample Households – Weekday Tolled Miles Driven / Week



Expansion of Experimental Results

- Sample of 275 HHs (enriched for transit access and vehicle fleet size)
- Recruitment process contacted in excess of 100,000 HHs
- Many HHs did not meet eligibility requirements, refused to participate, or failed to complete equipment installations

- **CHALLENGE:** to generalizing the research findings to the broader population

- **SOLUTION:** careful experimental design where sufficient HH level information was collected from all contacted HHs
  - allowing the sample enrichment to be reversed
  - controlling for self-selection and attrition bias

Post-Experiment Analysis

- **Disaggregation of price elasticities**
- **Projection of revenues and other system level consequences**
- **Examination of participant perceptions (e.g. technology and privacy)**
- **Additional systems architecture:**
  - Data protection and privacy
  - Verification and enforcement systems
  - Ancillary geo-positioning capabilities (e.g. microgyro, DSRC, GSM)
  - Vehicle Infrastructure Integration (VII)

Some findings to date

- The core technology for satellite-based toll systems is mature
- The quality of the underlying geodata base is a crucial factor
- On its own, GPS signal reception quality in downtown Seattle is inadequate for commercial deployment
- An arterial tolling system has different design requirements than a freeway only system
  - Short length trips may result in a few trips without sufficient location data
  - Digital characterization of roadway network is significantly more complex
  - On board unit storage limitations, a solvable problem
  - Enforcement…
- Significant deployment issue is the installation of hardware

Fairness of Road Pricing

- Direct use charging addresses existing horizontal inequalities
  - Across users groups (e.g. vehicle classes)
  - Across geography (e.g. urban/rural)

- Issues of vertical equity (across income classes) may remain, and are best addressed through a comprehensive treatment of both revenue and expenditure policies

- Road financing that improves overall economic efficiency leaves society with greater available resources to address equity concerns

Privacy

- Privacy questions involve what data leaves the vehicle, and what safeguards are in place to limit its availability and use.
- It may be necessary to design an approach where only “generic” facility use data is used by a central billing system.
- Audit/dispute functions can be preserved through temporarily storing detailed location data within the vehicle.
- Ultimately, any charging system must be technically verifiable and legally enforceable, within bounds of what is politically acceptable.

Outlook

- Project will show general feasibility of GPS-based solution for tolling applications in US
- Successful operational results may influence long-term planning and policy making in the Seattle region and elsewhere
- Important policy questions such as privacy and equity will be better understood
- Large-scale deployment of a GPS-based tolling solution depends on a viable business model and public acceptance of underlying concepts

For more information contact:

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